Code-1
CAT--05

Methods of Confusion in a Pattern Matching Task*

James A. Duke

Ames Research Center
Moffett Field, Calif.

Experimentation in the area of form and pattern perception has often involved the use of methods of degrading forms or patterns in order to make them more difficult to identify (e.g., Arnoult, 1954; Attneave, 1955; Hillix, 1960). The methods employed to produce this degradation have been nearly as varied as the number of experiments. The question arises as to whether it is possible to equate, behaviorally, these methods of producing degradation.

A common method for producing stimulus patterns has been to select randomly cells to be filled in a matrix. To produce degradation patterns, cells in the original matrix (the prototype) are manipulated in some fashion. These manipulations have included adding (French, 1954), displacing (Hillix, 1960), or changing the state of (Arnoult and Price, 1961) cells in the prototype.

The addition of cells is described here as augmentation. The moving of cells has been labled displacement i.e., moving cells to a new location. Changing the state of a cell has been labled distortion. This involves randomly choosing a cell and changing its state, i.e., if a randomly chosen cell is filled, it is changed to the unfilled state but if an unfilled cell is chosen, it is filled. A fourth method of degradation investigated in the present experiment is deletion. This involves subtracting elements from the prototype pattern to produce degradation.

Each of the above methods allows an experimenter to vary the extent of degradation. That is, any of these types of degradation can vary as to the

_____

number (percentage) of cells changed. Hereafter this will be designated as the level of change.

The present experiment investigated judgments of similarity by asking subjects to judge which of two test patterns was more similar to a third pattern, the test patterns consisting of all combinations of the types of degradation described above.

Method

Stimuli. Five prototype patterns were generated by randomly filling the cells in an 8 x 8 matrix with a probability of 0.5. The degradation patterns were constructed by either adding (augmentation), subtracting (deletion) changing (distortion) or displacing (displacement), a given percentage of cells in each of the prototypes. The levels of degradation (percentage of cells degraded) investigated varied from 0 to $28^o/o$ in steps of $4^o/o$ (0,3,5,8,10,13,15, or 18 cells). On any trial a pair of degradation types e.g., augmentation and deletion, were presented at the same level of degradation; there was never an intermixing of levels.

Apparatus. The principle components of the apparatus were a paper tape reader, a paper tape punch, a scanner, three 8 x 8 matrices of lights and a closed circuit television system (Fig. 1). The light matrices were constructed from lucite plastic hexagon rods. Matrix cells were lit individually with virtually no spill of light into adjacent cells. When adjacent cells were lit the separation between cells was perceptible. In addition, there was a perceptible difference in the brightness of the individual cells. By manipulating focus on the T.V. camera and contrast on the T.V. monitors, it was possible to eliminate the slight separation and brightness differential

between cells (Fig. 2). The subjects viewed the patterns projected on individual 14 inch T.V. monitors. In addition to presenting the desired image, the T.V. system allowed 3 subjects to be tested at a time.

The apparatus was automatic to the extent that the stimulus patterns were programmed on paper tape and read through the tape reader. The time intervals were controlled by electronic circuitry. The subject's responses and coded information from the program tape were stored in the scanner and subsequently recorded on paper tape.

Subjects. Subjects were obtained from a subject pool maintained by the laboratory for use in psychophysical research. A total of 33 subjects began the experimentation, 18 male college students ranging in age from 19 to 25 and 15 housewives ranging in age from 25 to 45. Eight subjects were dropped either because of experimental error or because of failure to complete all experimental sessions.

Procedure. The subjects were tested 3 at a time in a soundproof room. Plywood partitions separated each subject visually, and this coupled with auditory monitoring insured minimum communication between subjects. The subjects were instructed to indicate, by depressing one of two switches placed within easy reach, which of the two bottom patterns appearing on the screen was more similar to the top pattern. After all subjects had responded, another set of patterns appeared.

Each group of three subjects responded to 480 sets of patterns each day for 15 days. For any day, each group of subjects was presented all possible combinations of the five prototypes, eight levels and four kinds of degradation, an equal number of times. A total of 15 program tapes were randomly generated so that no group of three subjects received the same order of

presentations on any day. Left-right response bias was controlled by counter-balancing the degradation types.

The male and female subjects were treated as two separate groups and tested in separate three-week periods.

Results and Discussion

A total of 7200 responses were recorded for each subject over the experimental period. In some cases where a response was not recorded, due to machine error, a random choice was inserted to facilitate machine analysis. This "filling in" of responses constituted less than .05 per cent of the 187,200 total responses.

The proportion of responses to each combination of degradation at each level for both sexes was obtained. Fig. 3 is a plot of the proportion of responses for each of the four kinds of degradation summed over level and sex. While it is immediately apparent that these kinds of degradation are not behaviorally the same, this sort of description obviously obscures any comparison between the various combinations of degradation as they were presented experimentally. Fig. 4 are plots of all possible combinations of degradation with data for each sex plotted separately. From inspection of these graphs it can be seen that generally the trends for both the males and females are the same but it appears that the magnitude of the preferences is different. It can also be determined that the response choices were dependent on the level of degradation.

To test for the effects of sex and level of degradation, analyses of variance were run for each possible combination of stimuli. These were treatment X subject type analyses and are summarized in Table 1. The data used in these analyses were the number of responses to one of the kinds of

degradation in a pair summed over all experimental sessions. Tests for homogeneity of variance were conducted and indicated that this assumption was met.

From these analyses it was found that for any combination of degradation the level of degradation was a significant factor; in every analysis this factor was significant. On those factors where augmentation was paired with each of the other types of degradation, the interaction between level of degradation and sex is significant but not in combinations where augmentation is absent. From the curves (Fig. 4) it can be seen that in these same augmentation combinations, the males consistently chose augmentation patterns with greater frequency than did the females. Caution must be exercised in attempting to interpret the sex differences, however, since two distinct age groups and different test periods are represented on this factor as well as sex.

The experimental sessions were extended over a three-week period to determine whether experience with the task would change the preferences. Fig. 5 shows the proportion of responses to one kind of degradation in all the possible combinations, summed over level. It is obvious that the response choices changed over sessions. While this finding needs further investigation, it suggests that previous research utilizing tasks of this kind might have obtained different results had experience with the task been substantially increased.

Table 2 presents the proportion of responses to each type of degradation for each of the 5 prototypes. As the table is read horizontally it can be seen that there is little change in the proportion of responses to each prototype. These data are presented to show that the differences among

prototypes did not appear to affect the results.

Conclusions

It can be concluded that different types of degradation influence response choices in pattern perception studies and that these choices are also influenced by the amount or level of degradation. This study also points out the problems of a limited amount of experience with a task involving the types of stimuli employed. While the analysis failed to show consistent sex differences across all the combinations of degradation investigated, it did show that in half the cases there was an interaction between the level of degradation and the sex factor.

Studies, now in the analysis state, have been run to replicate the present experiment, using different stimuli. Programs are also being written to analyze the data in a manner suggested by Arnoult and Price (1961). This consists of correlating performance with the physical attributes of the stimuli, namely, finding the number of pairs, triplets, quadruplets, etc. of cells in common between the prototype and test stimuli.

-7-

Augmentation (Augmentation/Distortion)

Source	MS	df	F
Sex (s)	15195.44	1	13.02*
error (a)	1167.38	24	
Level (L)	1890.50	6	26.47*
S x L	388.65	6	5.44*
error (b)	71.43	144	

Augmentation (Augmentation/Deletion)

Source	MS	df	F
Sex (s)	13285.86	1	4.59**
error (a)	2892.67	24	
Level (L)	254.03	6	2.82*
S x L	245.40	6	2.72*
error (b)	90.23	144	

Augmentation (Augmentation/Displacement)

Source	MS	df	F
Sex (s)	5931.44	1	2.7
error (a)	2196.94	24	
Level (L)	6860.79	6	61.15*
S x L	823.28	6	7.34*
error (b)	112.20	144	

Distortion (Distortion/Deletion)

Source	MS	df	F
Sex (s)	2084.92	1	1.38
error (a)	1515.63	24	
Level (L)	4164.03	6	50.16*
S x L	74.70	6	<1.00
error (b)	83.02	144	

Distortion (Distortion/Displacement)

Source	MS	df	F
Sex (s)	2540.66	1	4.48**
error (a)	567.71	24	
Level (L)	373.27	6	10.05*
S x L	47.07	6	1.27
error (b)	37.15	144	

Deletion (Deletion/Displacement)

Source	MS	df	F
Sex (s)	6564.02	1	2.81
error (a)	2329.54	24	
Level (L)	9099.38	6	69.57*
S x L	150.22	6	1.15
error (b)	130.80	144	

Table 1 Summary of analyses of variance for each degradation combination $*P > .01$ $**P > .05$

Prototype

Kind of Confusion	1	2	3	4	5
Augmentation	.28	.29	.31	.29	.29
Distortion	.29	.29	.29	.29	.30
Deletion	.22	.21	.18	.22	.20
Displacement	.21	.21	.22	.21	.21

Males

Prototype

Kind of Confusion	1	2	3	4	5
Augmentation	.25	.24	.25	.24	.25
Distortion	.30	.31	.31	.31	.32
Deletion	.25	.25	.24	.27	.24
Displacement	.19	.21	.20	.18	.19

Females

Table 2. Proportion of responses to each prototype summed over days for male and female subjects.

References

Arnoult, M. D. Shape discrimination as a function of the angular orientation of the stimuli. J. exp. Psychol., 1954, 57, 323-328.

Arnoult, M. D., & Price, C. W. Pattern matching in the presence of visual noise. J. exp. Psychol., 1961, 62, 372-376.

Attneave, F. Symmetry, information & memory for patterns. Amer. J. Psychol., 1955, 8, 209-222.

French, R. S. Pattern recognition in the presence of visual noise. J. exp. Psychol., 1954, 47, 27-31.

Hillix, W. A. Visual pattern identification as a function of fill and distortion. J. exp. Psychol., 1960, 59, 192-197.
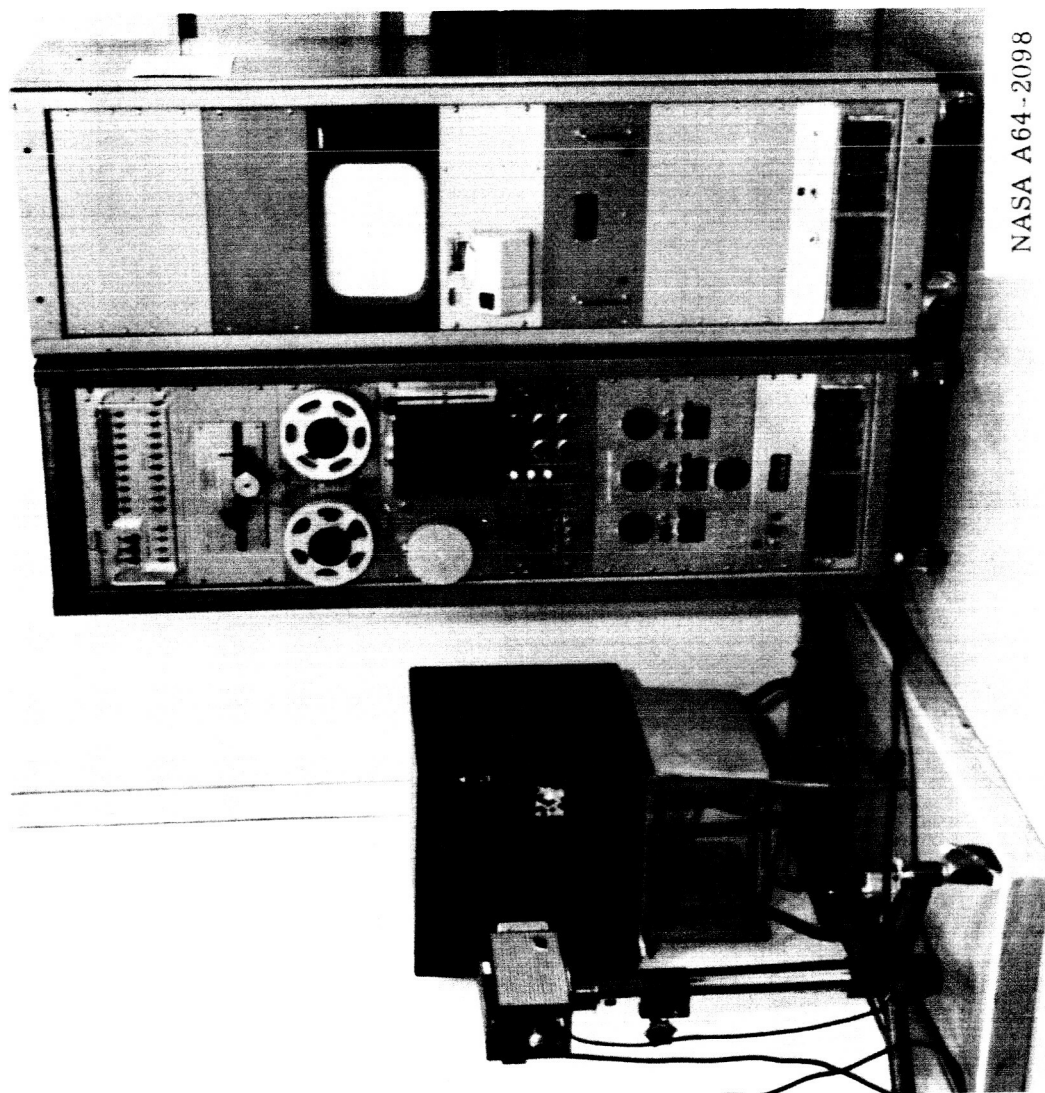
Fig. 1 Apparatus used in pattern perception studies.

NASA A64-2098
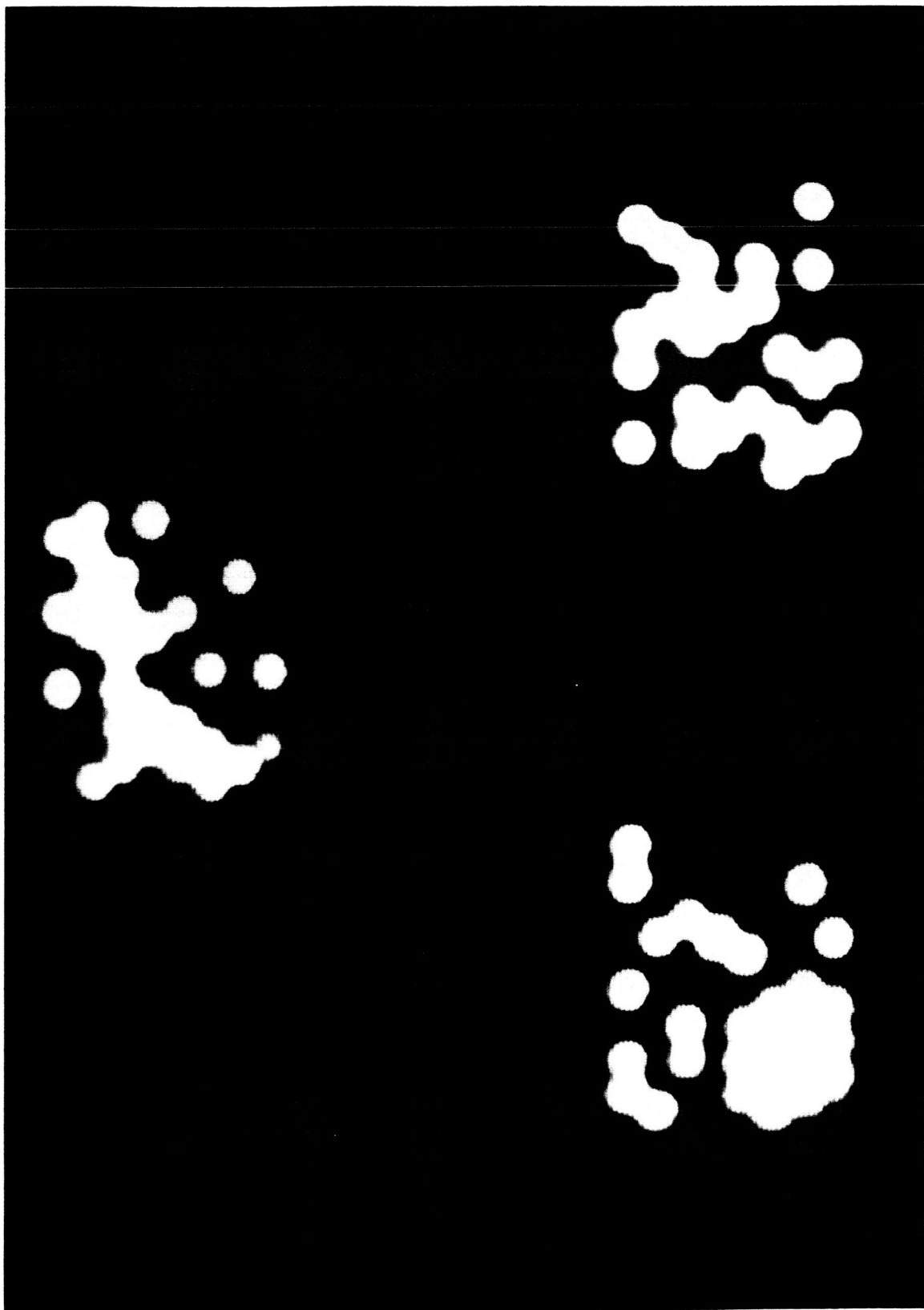
Fig. 2 An example of one of the patterns used in the experiment.

A-34266-4
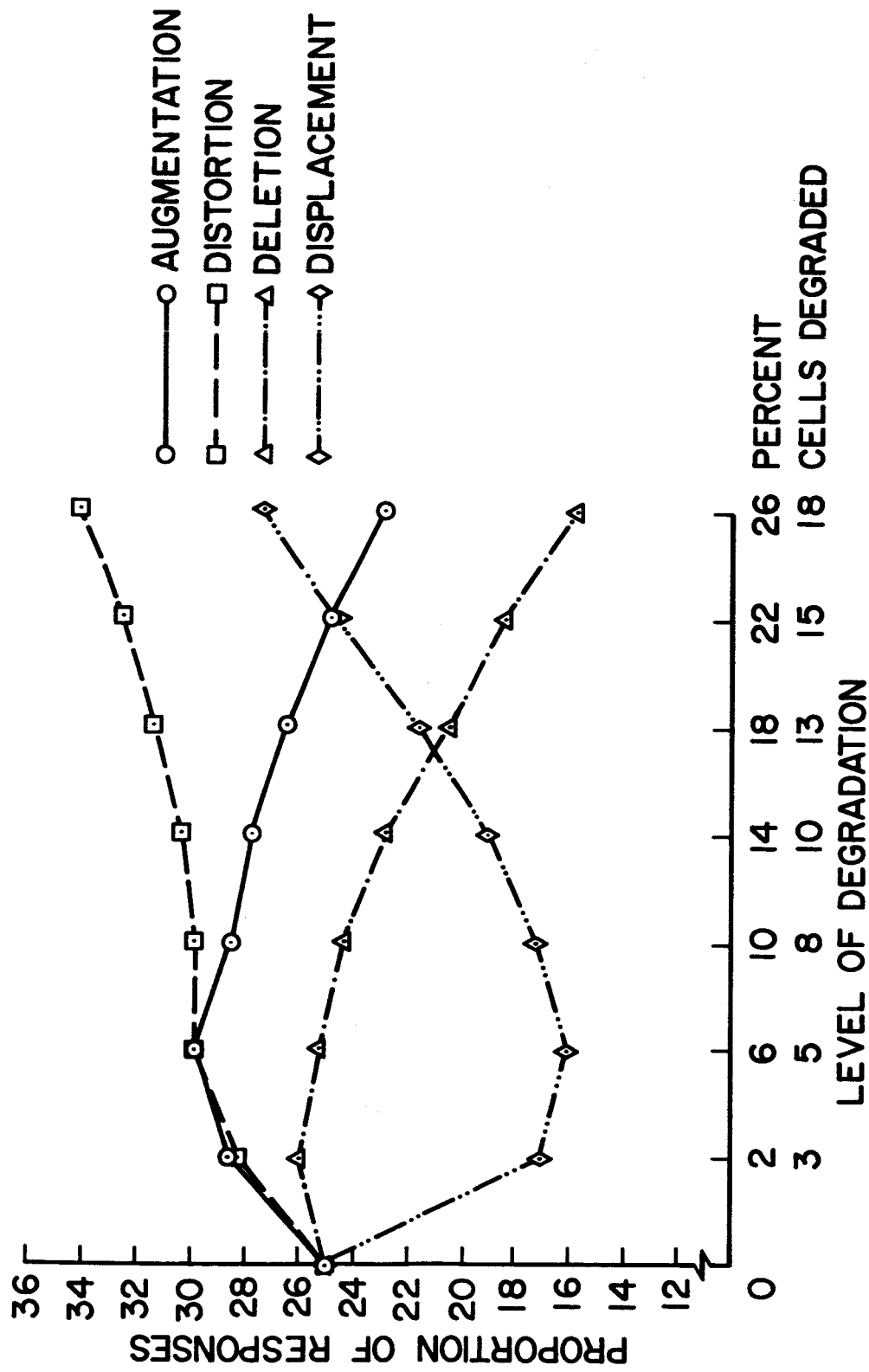
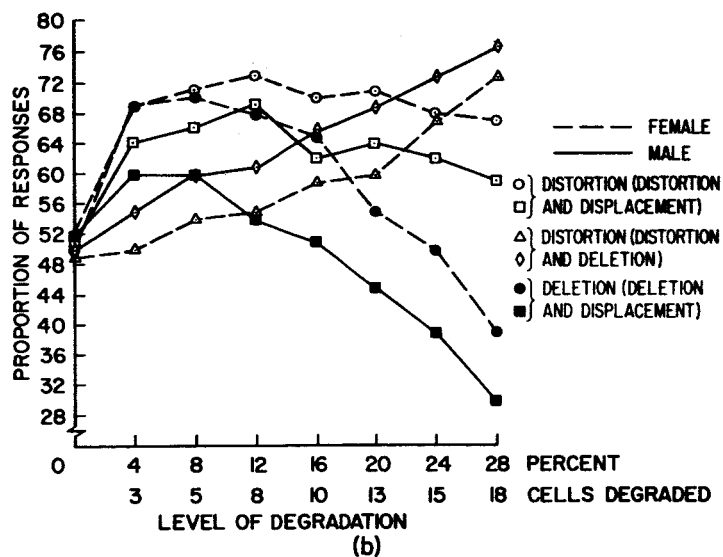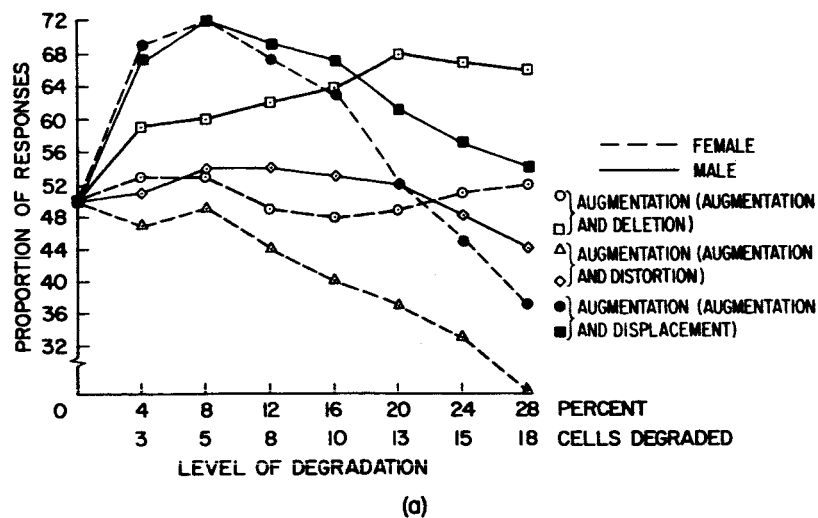Fig. 3 Proportion of responses to types of degradation as a function of level.

Fig. 4 Proportion of responses to each kind of degradation for all combinations over level.
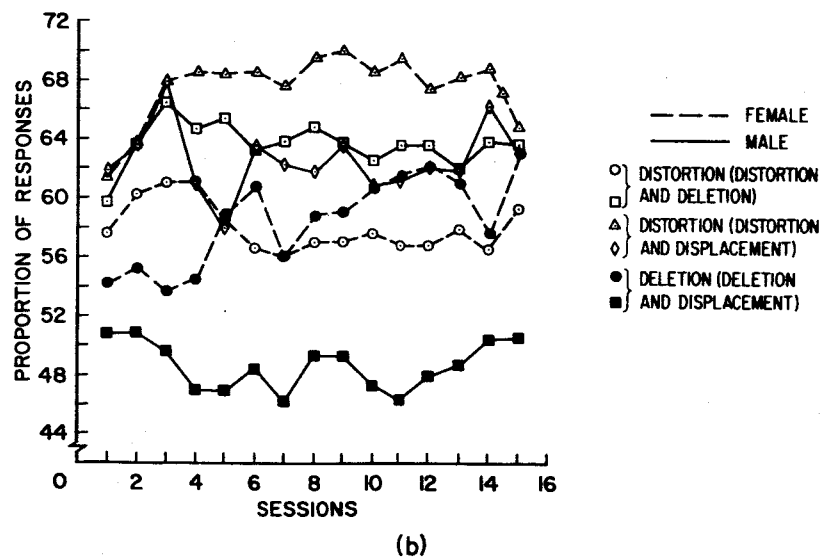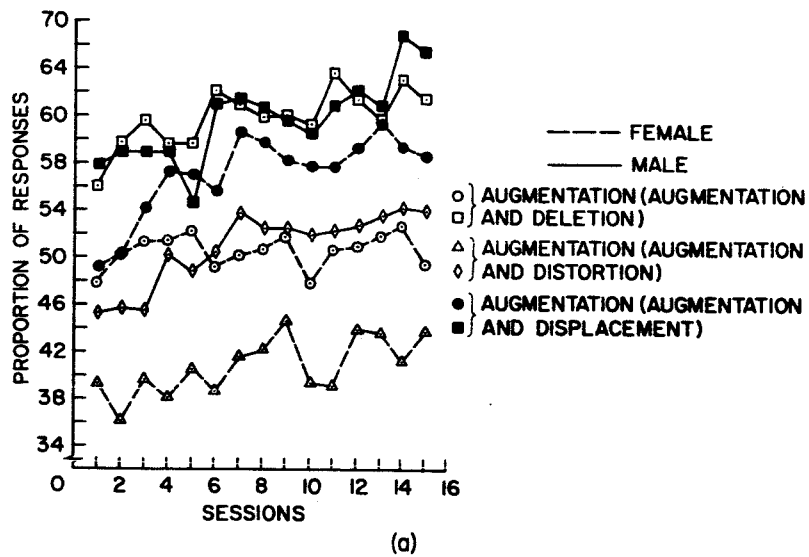
Fig. 5 Proportion of responses to one kind of degradation for all combinations
of degradation over experimental sessions.